The Dawn Mission To Vesta and Ceres

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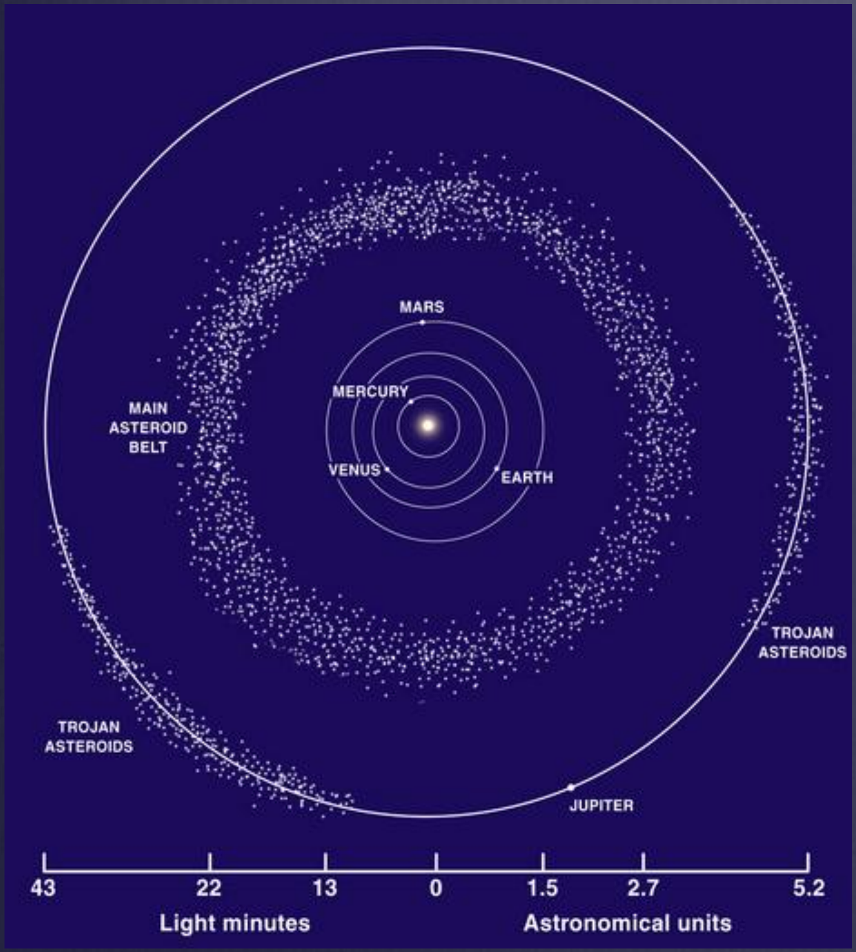
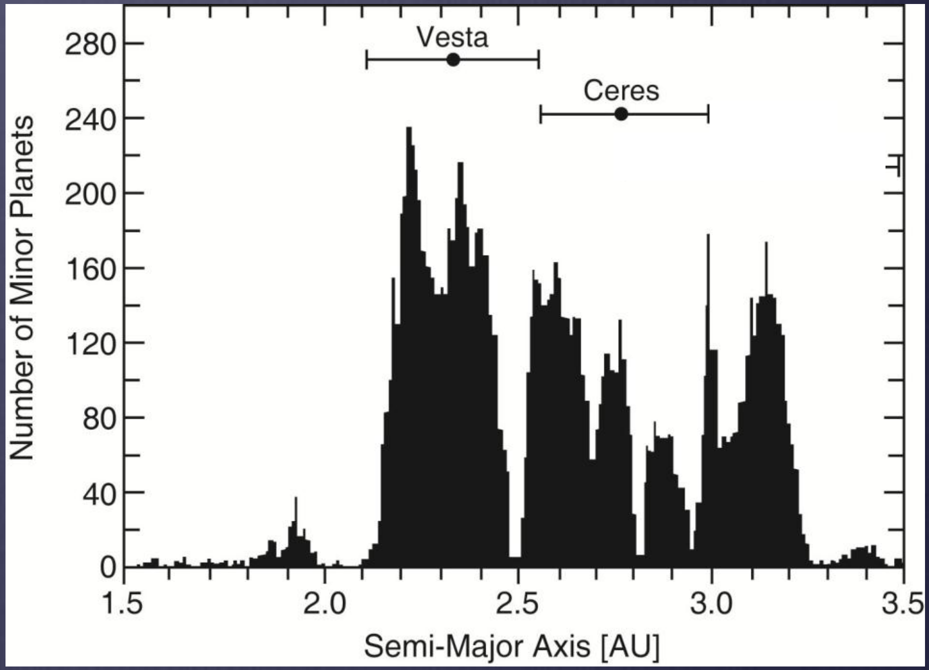
Where Are Vesta and Ceres?





Drier

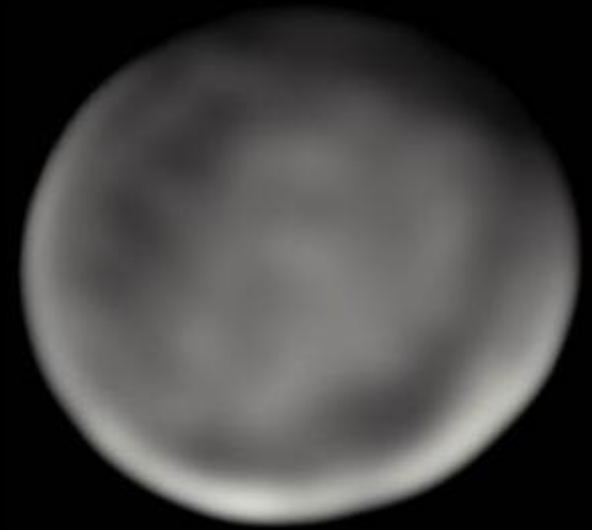
Wetter

Frost Line

Vesta and Ceres

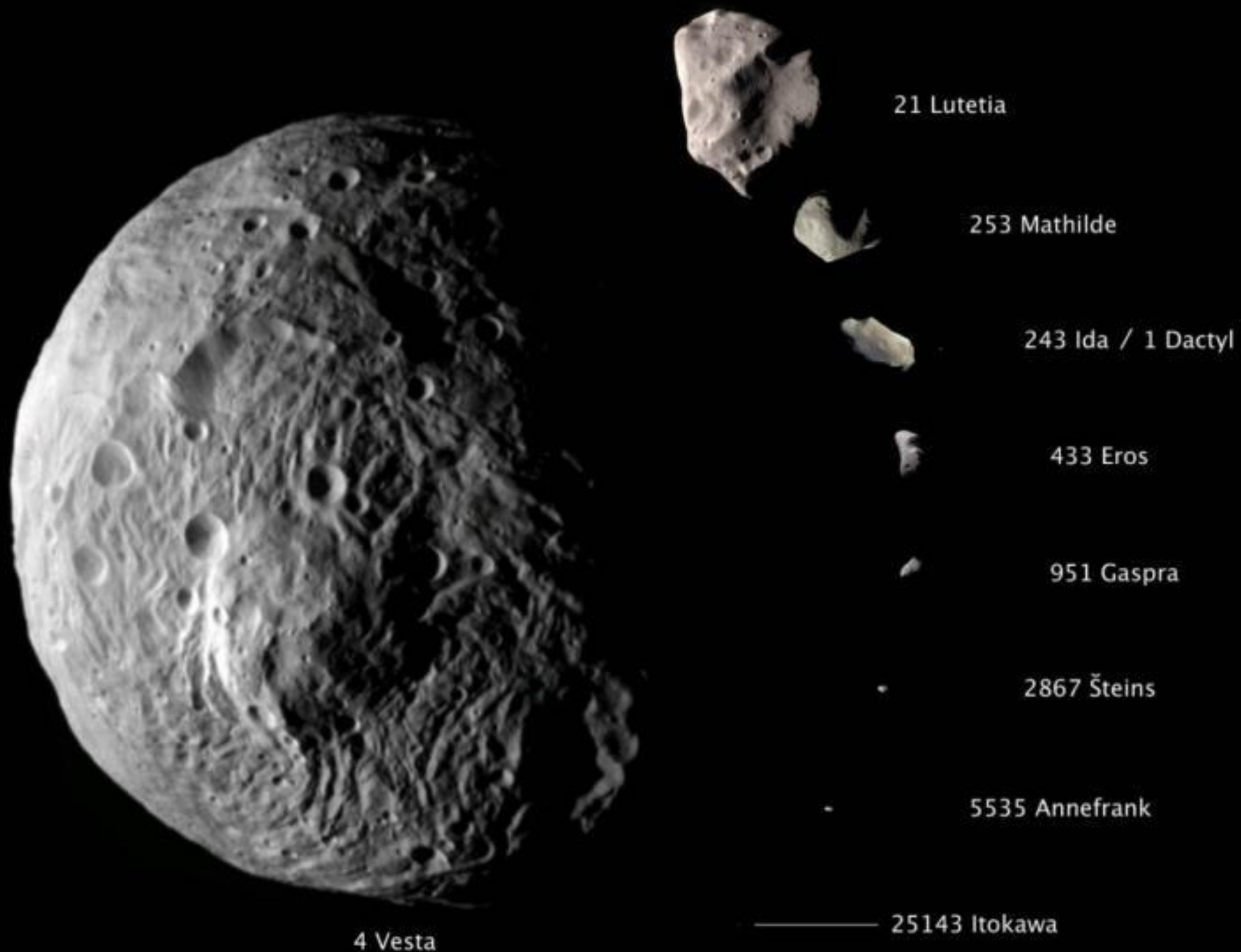
	Vesta	Ceres
Discovery (year)	1801	1807
Mean Radius (km)	265	480
Spin Rate (hours)	5.3	9.1
Pole Declination (deg)	42.2	59
Pole Right Ascension (deg)	309	291
Orbital Inclination (deg)	7.1	10.6
Orbit Period (yrs)	3.6	4.6
Spectral Type	V	G
Semi-major axis (AU)	2.4	2.7
Eccentricity	0.09	0.08

Vesta Image from Dawn



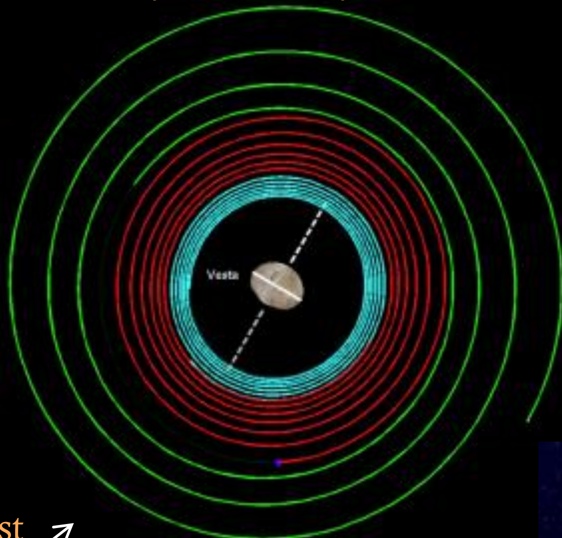
Ceres Image from Hubble

Size Comparison

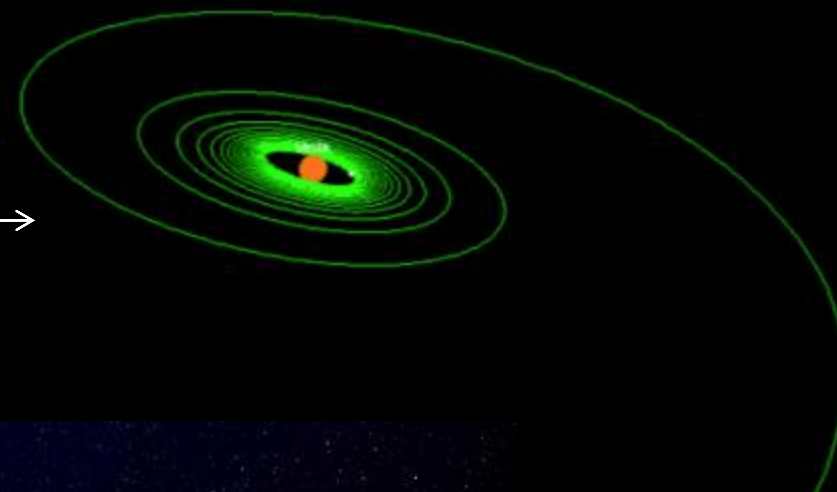


Mission Itinerary

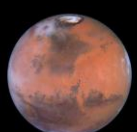
Vesta
July 2011 – July 2012



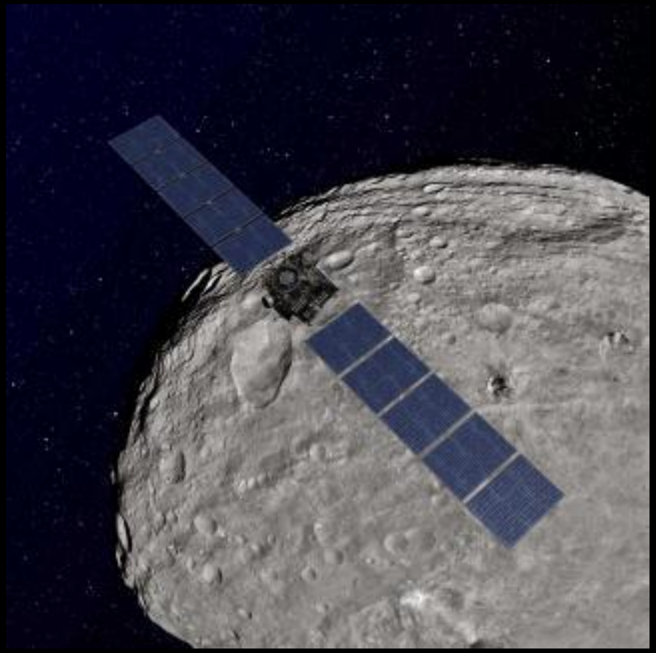
Ceres
Feb 2015 – July 2015



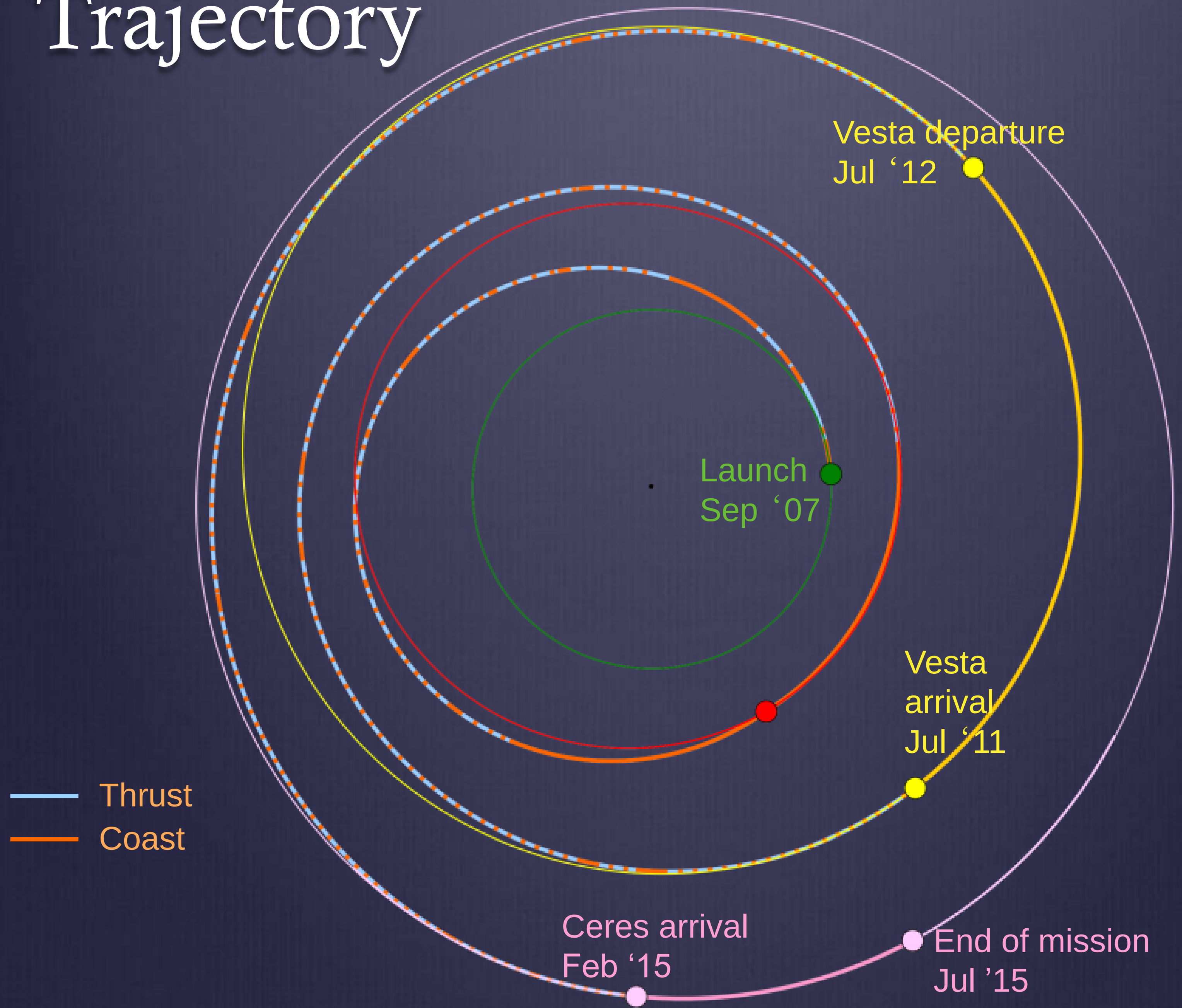
Mars Gravity Assist
Feb 2009



Launch
Sep 2007



Trajectory

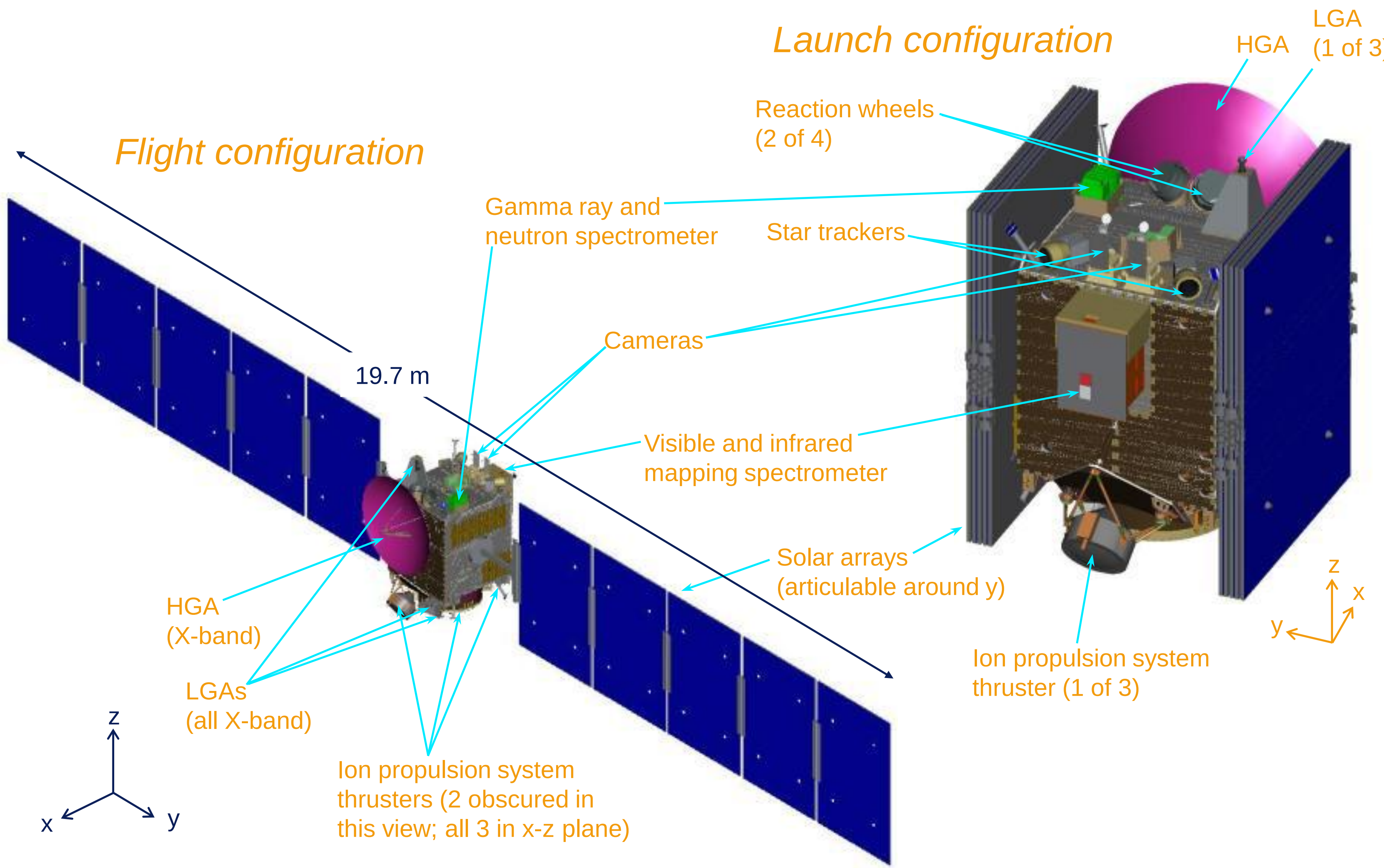


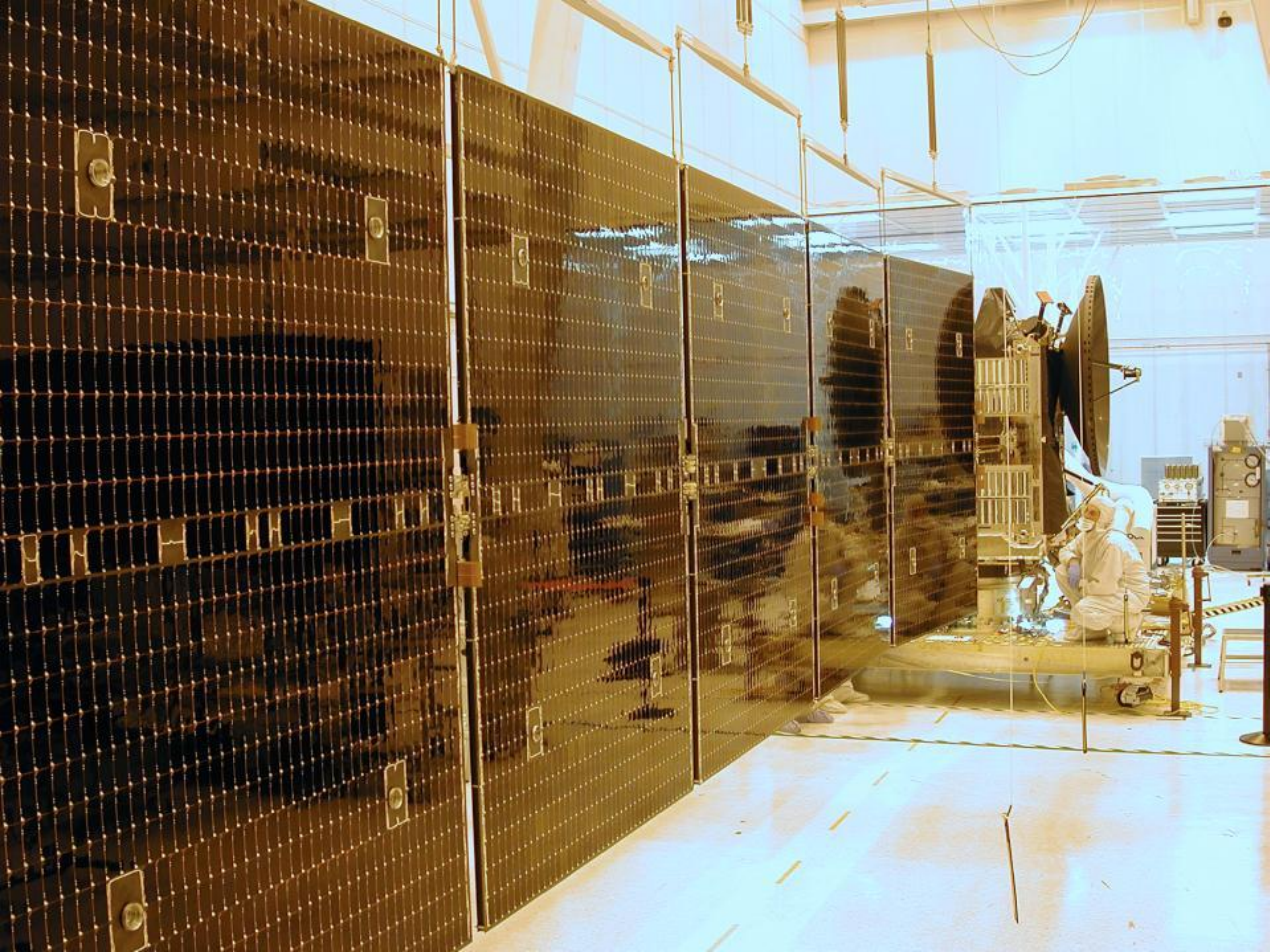
Vesta departure
Jul ‘12
Launch
Sep ‘07
Vesta
arrival
Jul ‘11
Thrust
Coast
Ceres arrival
Feb ‘15
End of mission
Jul ’15

Spacecraft Overview

Mass: 1218 kg (launch)
Length: 19.7 m
Power Generation (1 AU): 10.3 kW
Single Fixed HGA + 3 LGAs (X-band)
3 ion thrusters + 12 hydrazine thrusters
425 kg Xe + 45 kg Hydrazine
4 Reaction wheels
Data Storage: 8 Gb

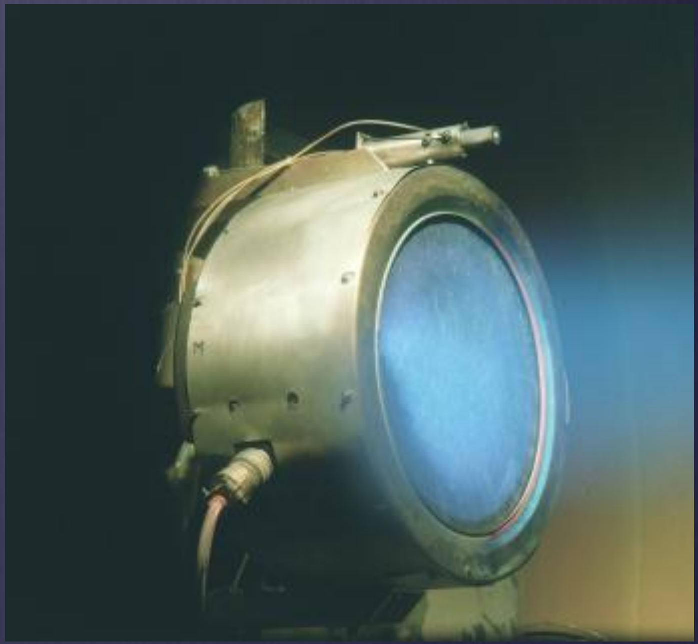
Flight System Configuration





Ion Propulsion

- Ion propulsion was first flown as primary interplanetary propulsion on Deep Space 1 in 1998
- On Dawn, ion propulsion is used not only to get from one celestial body to another but also to transfer between orbits, maintain orbits, and capture and escape Vesta and Ceres
- Ion Propulsion enabled the Dawn mission, where the post-launch delta-V requirements were over 11 km/sec (equivalent to the delta-V delivered by the launch vehicle)
  - Using traditional chemical propulsion as the primary system would require 10 times the propellant and an Atlas V just to get to Vesta



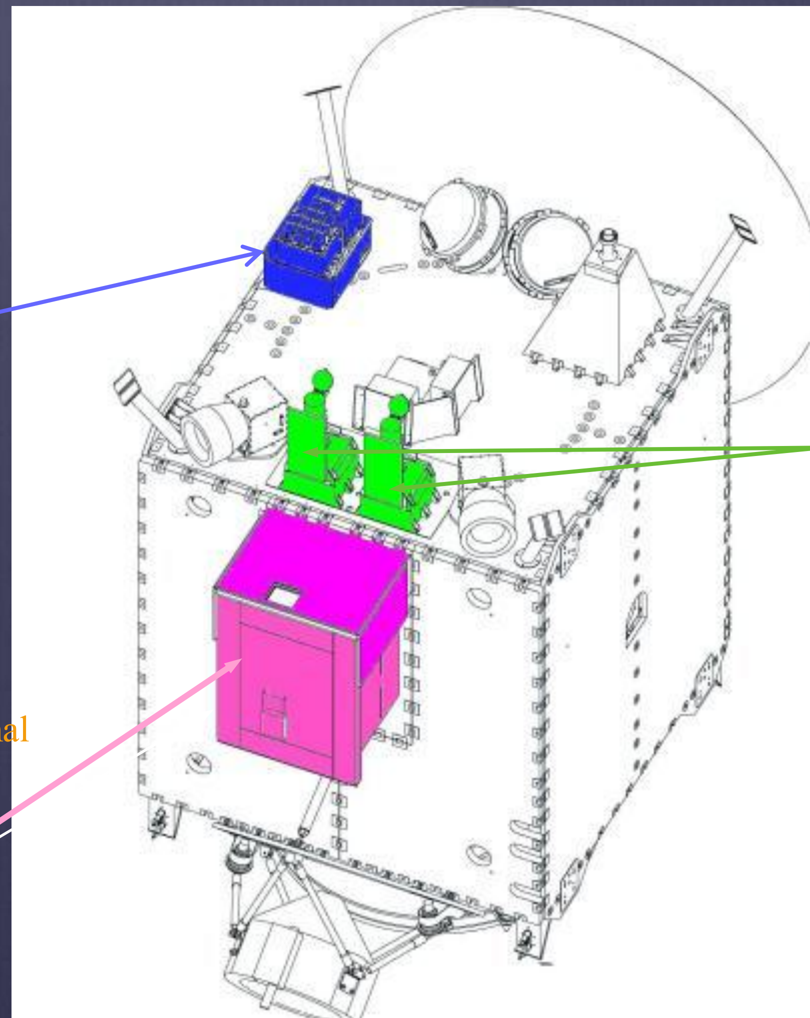
Payload

γ-ray and neutron spectrometer (GRaND)

- Mapping of elemental abundances
- Built by LANL and operated by PSI

Visible/IR mapping spectrometer (VIR)

- High resolution mineralogical and thermal emissivity mapping (UV to 5 microns)
- Contributed by Italy's ASI



Cameras (2)

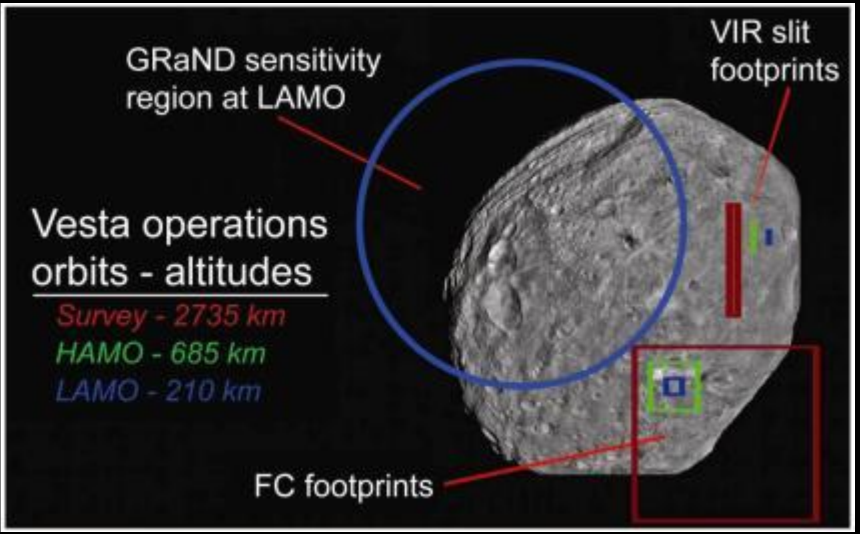
- Imaging science
- Navigation
- 1024 x 1024 pixels, 7 color filters
- Contributed by Germany's MPS & DLR

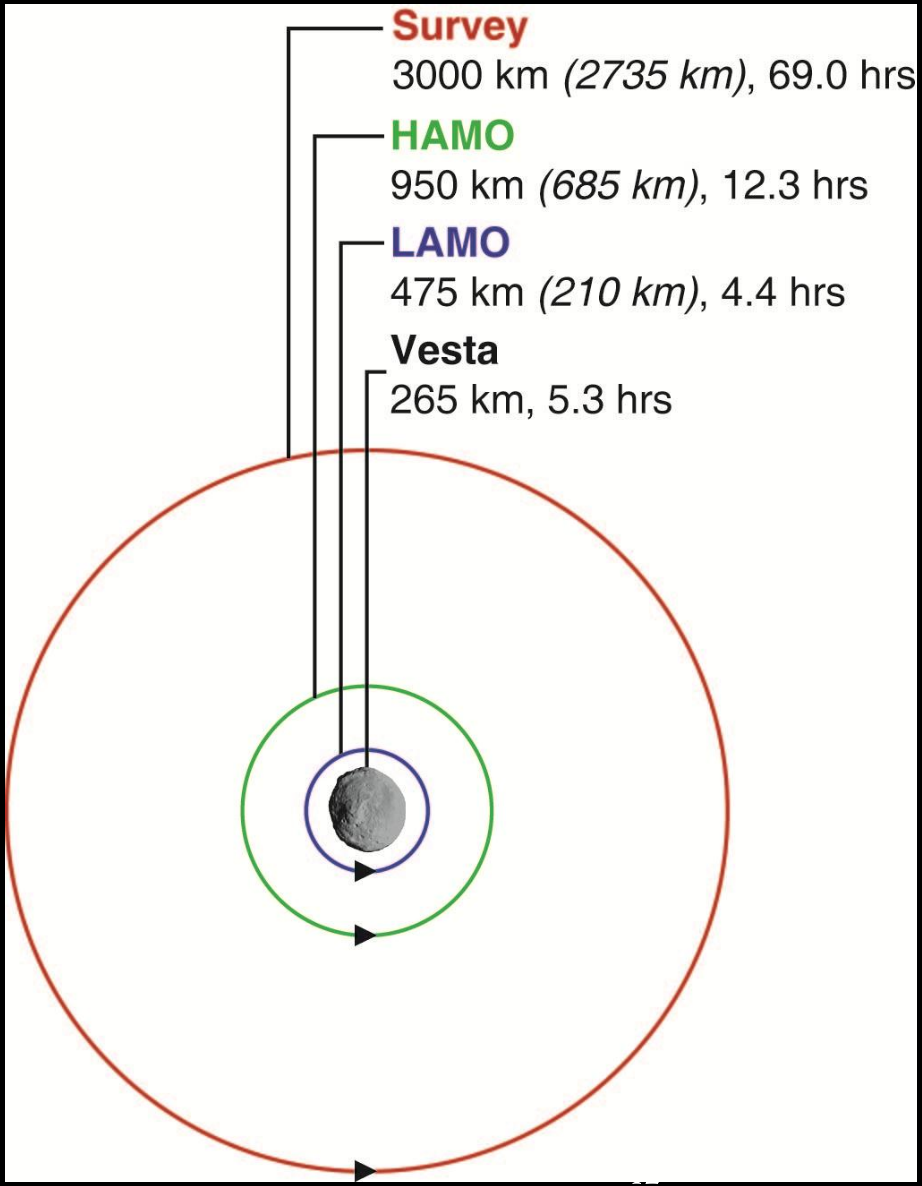
Gravimetry

- Accomplished with other flight and ground systems

Vesta Science Orbits

- Dawn began taking science data in a high *Survey* orbit on August 11
- It then used the ion propulsion system to transfer to the *High Altitude Mapping Orbit (HAMO)* which began September 30.
- Now it is in the *Low-Altitude Mapping Orbit (LAMO)* , arriving December 12.
- Dawn will then raise its orbit to perform a second HAMO, departs from Vesta, and repeat the same orbital strategy at Ceres





Vesta Observation Plan

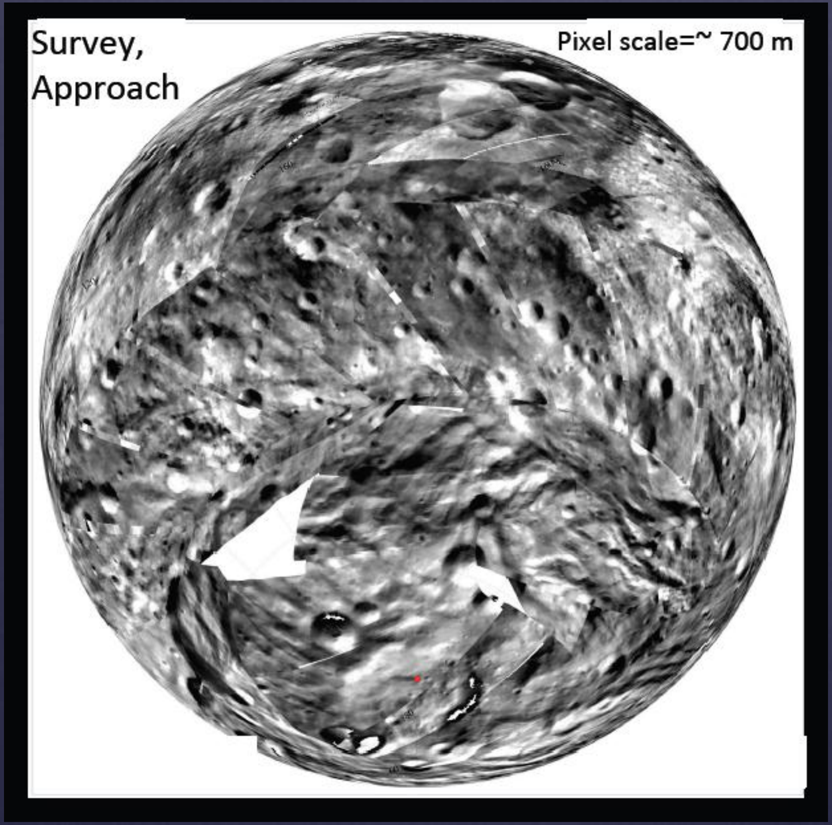
- Ap
  -
  - were
  -

July 17

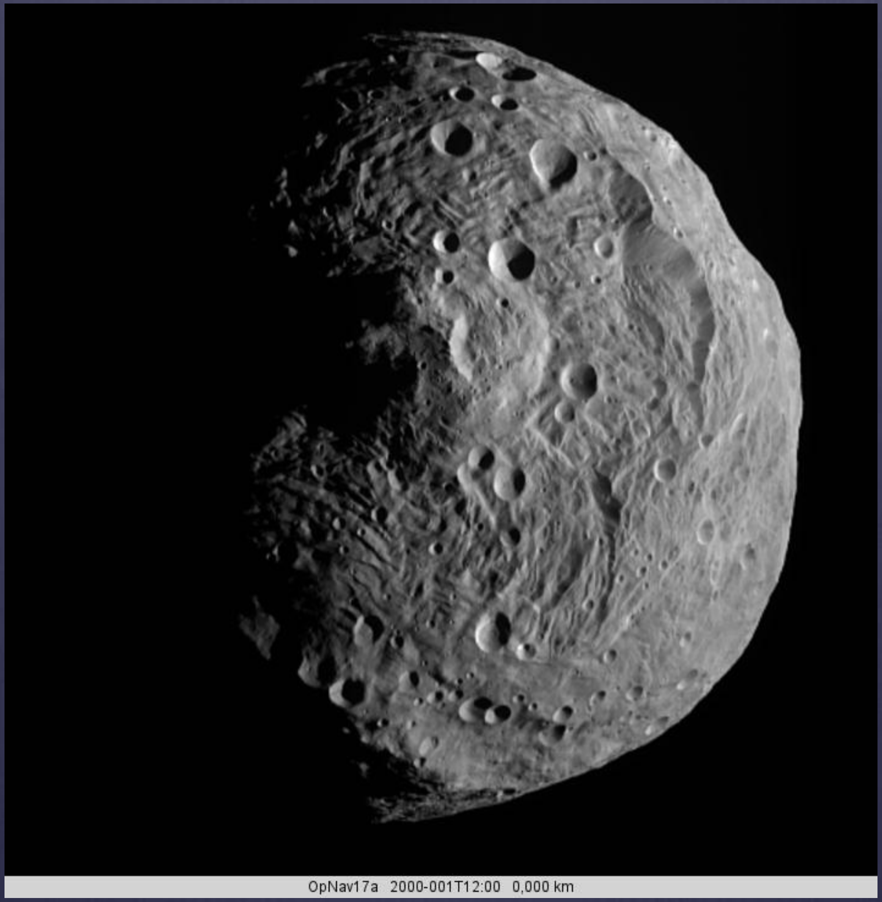
15,000 km

Vesta Observation Plan

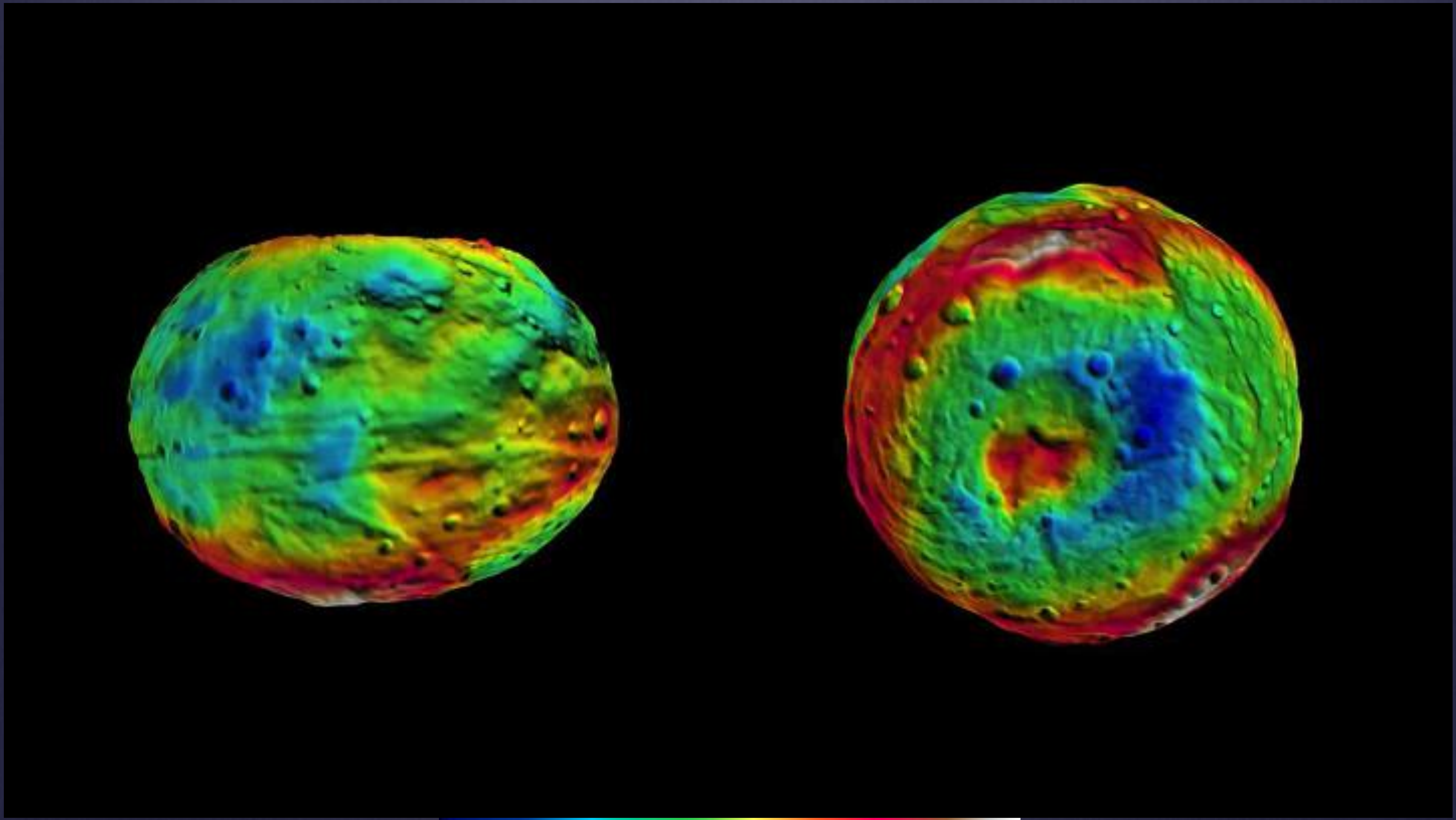
- **Survey**
  - Optimized for VIR observations
  - VIR global coverage using pushbroom imaging and scan-mirror image cubes
  - FC nadir and limb imaging
  - Multiple FC mosaics with full rotational phase coverage



South Pole View



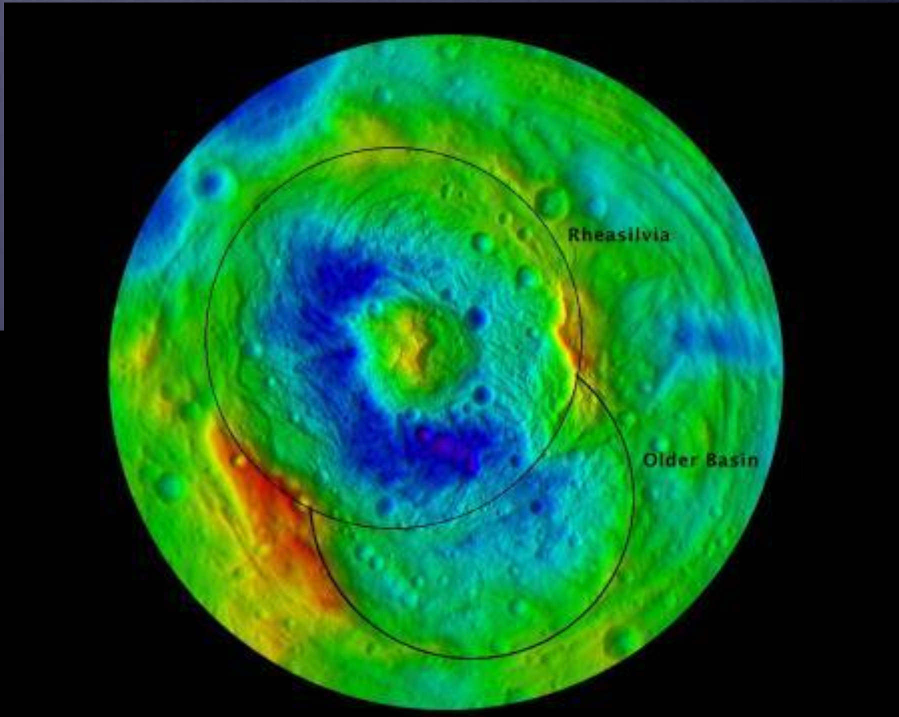
Global Topography



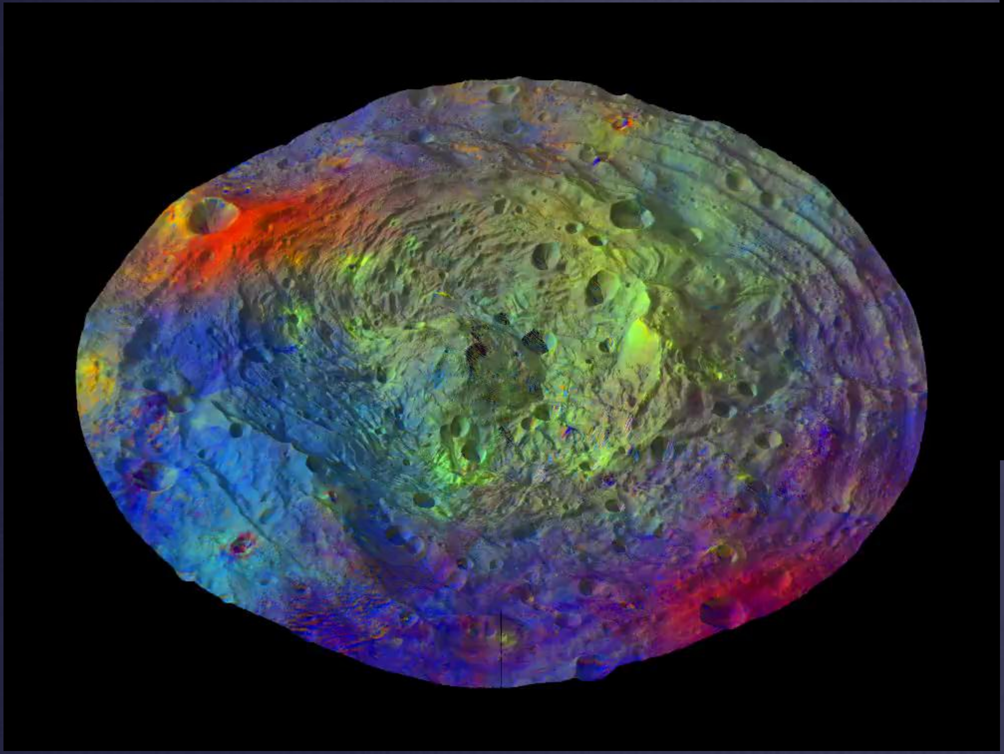
Relative to an ellipsoid of 285 x 230 km

South Pole

Rheasilvia is the largest crater (relative to body size) in the Solar System. Scaled to Earth, it would stretch from Washington DC, over the North Pole, to Tokyo



Colorized shaded-relief map showing identification of older 375-kilometer-wide impact basin beneath more recent Rheasilvia impact structure



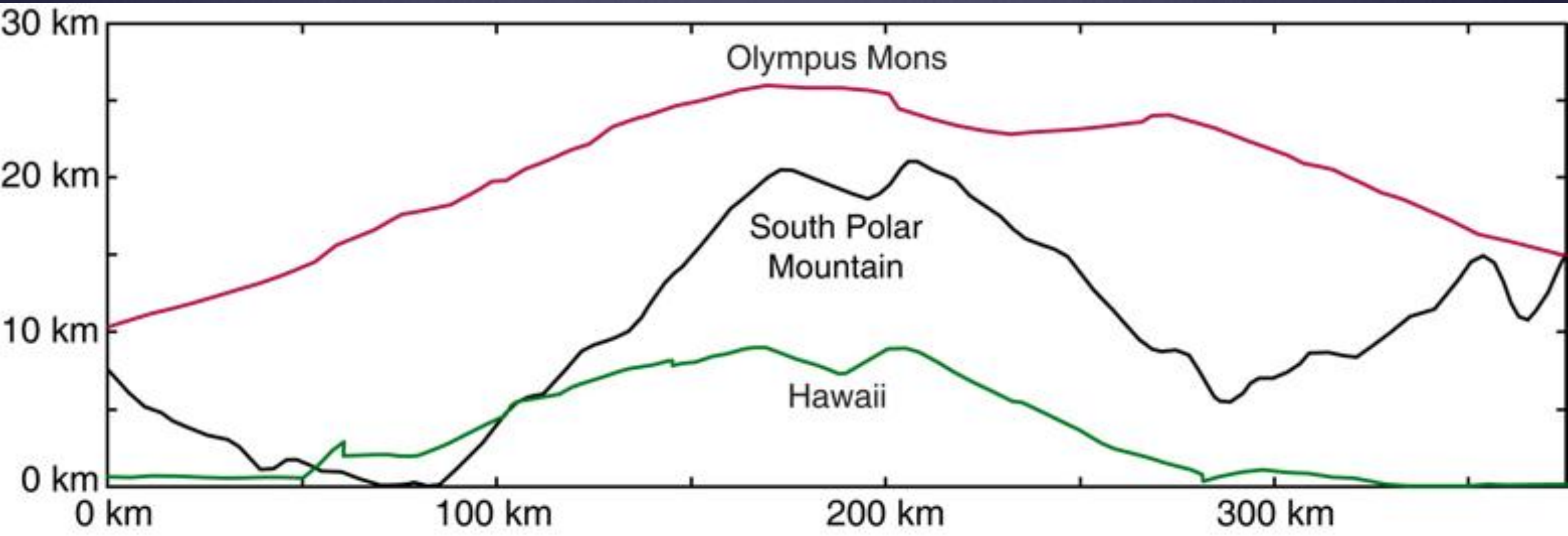
2x vertical exaggeration

Rheasilvia appears to have formed on top of an older basin, and may have launched large numbers of meteorites from Vesta to Earth

RheaSilvia = ~500 km diameter

Older crater = ~375 km diameter

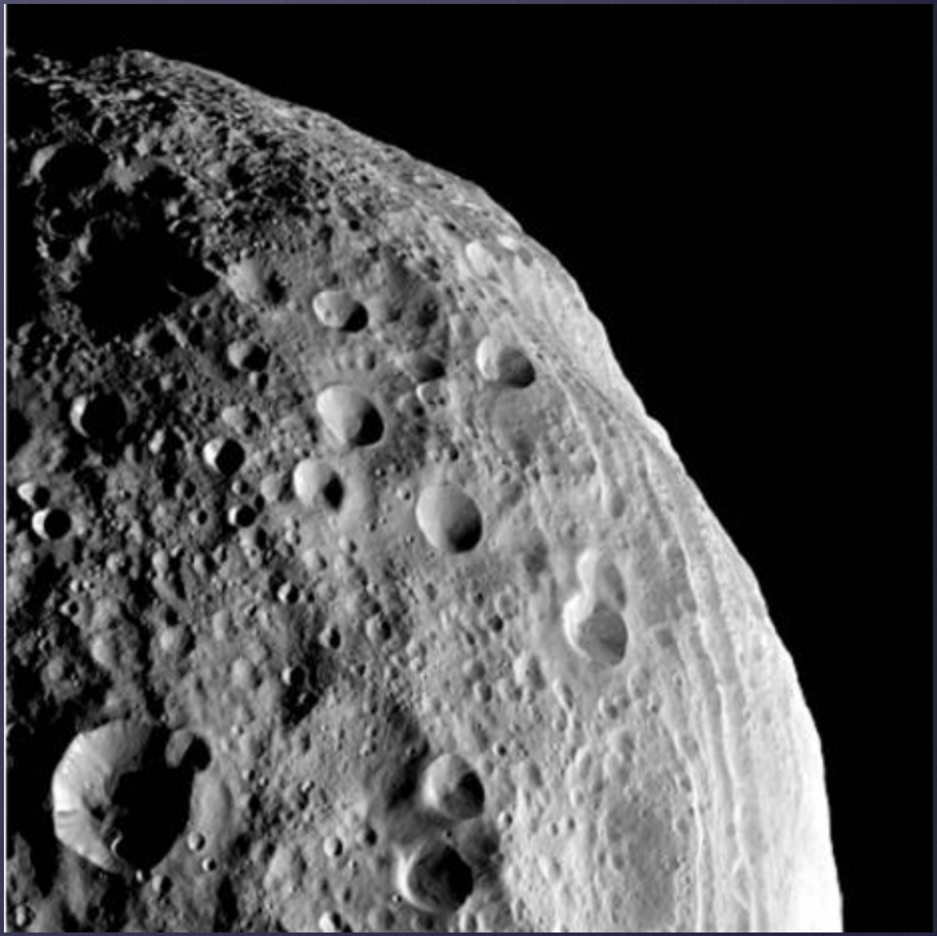
Topography Comparison



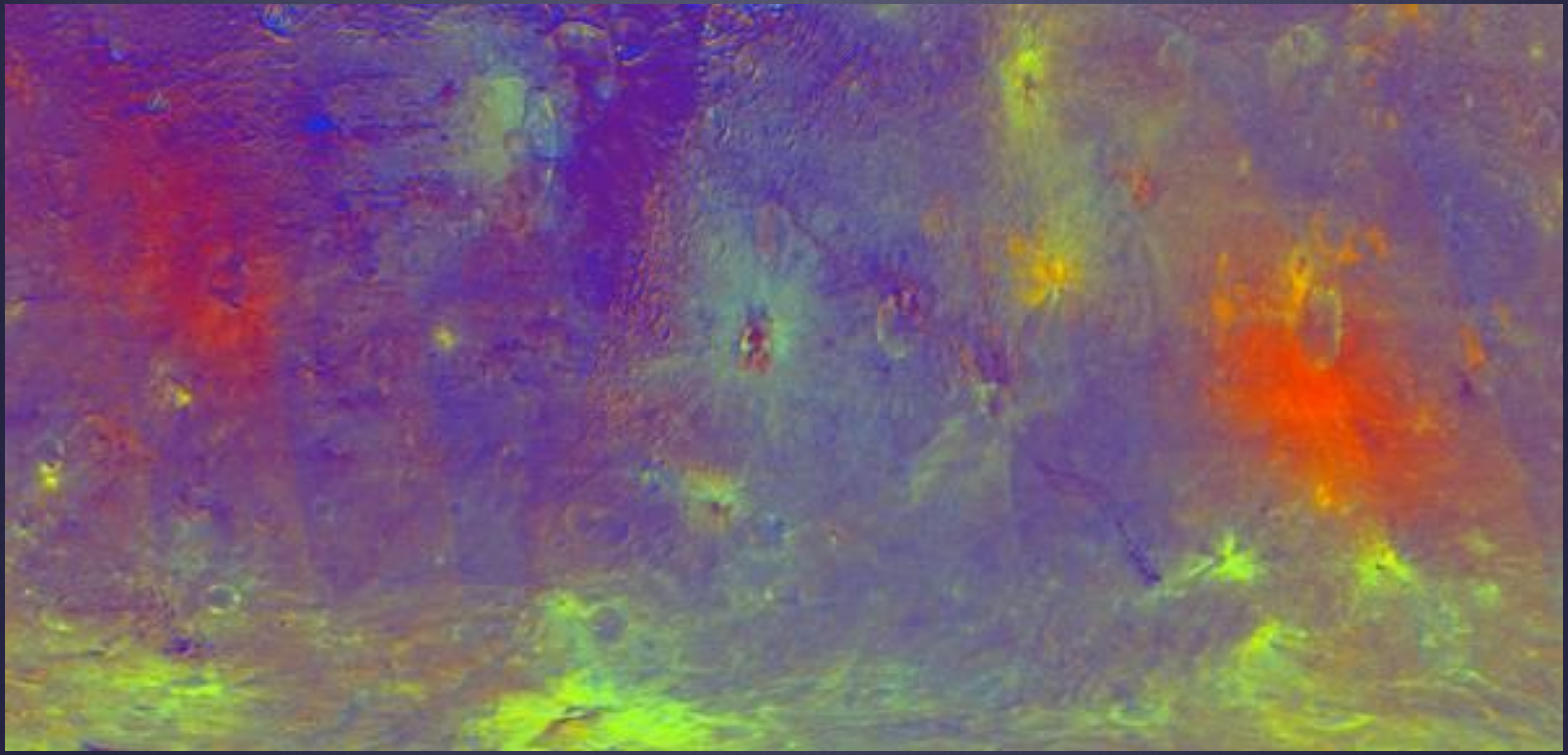
Rheasilvia's central peak is over 2X taller than Mt. Everest, and comparable to Olympus Mons on Mars

Giant Troughs

- Vesta has giant troughs.
- These appear to be caused by the giant impacts, reflecting significant changes in global stresses.
- There are many sets of smaller grooves or lineations all over the body



Vesta Is Colorful!



This false color image of Vesta’s surface constructed using framing camera color filter data shows deep ferrous absorption bands in the southern impact basin (green) and distinct material excavated by large impact craters in the north (red and orange). Blue areas have less spectral contrast.

Summary of Key Results To Date

- There is a dichotomy in number of craters between north and south.
- The north is heavily cratered and appears to be older
- The south was wiped clean with a giant impact.
- There is evidence of two giant impacts at the S. Pole of different ages
- Spectral variations indicate diversity in composition of the crust and chemical layering within the crust which is consistent with the concept of HEDs meteorites coming from Vesta
- Vesta's temperature ranges from 180 – 270 K
- Core size ~ 110 km radius (Iron)
- There are bright and dark materials that seem to be associated with cratering

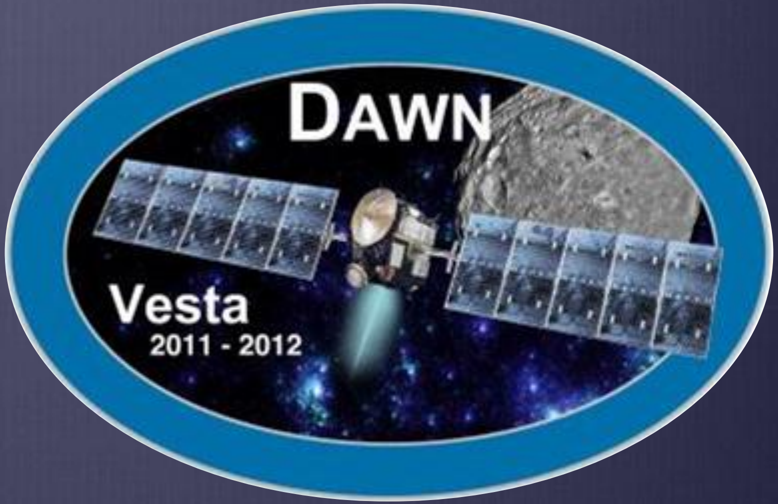
Dawn Spacecraft Thermal Overview

- Extensive redundancy using flight-proven assemblies from other Orbital and JPL spacecraft
- Ion propulsion system
- Solar array capable of producing more than 10 kW at Earth's distance from the Sun and more than 1 kW at Ceres's maximum distance
- Simple hydrazine reaction control Modular flight software based on design used on Orbview
- Core structure is graphite composite. Panels are aluminum core, some with aluminum facesheets and others with composite facesheets.

Component	Flight Quantity
MLI	33 m^2
OSRs	2.0 m^2
Heat Pipes	42
Heaters	194
Louvers	4 at 1.4m^2
Thermistors	186
Thermostats	208

Thermal Lessons Learned – What Went Well?

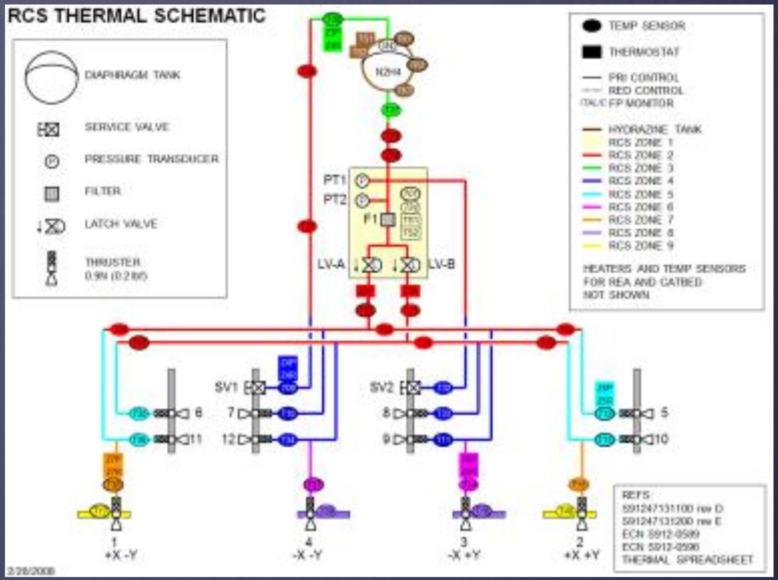
- No thermal related spacecraft safe-mode events during tour of Vesta
- Vesta thermally benign to Dawn, though it has an albedo of 0.41
- Most sub systems behaved as expected and the spacecraft remains healthy.

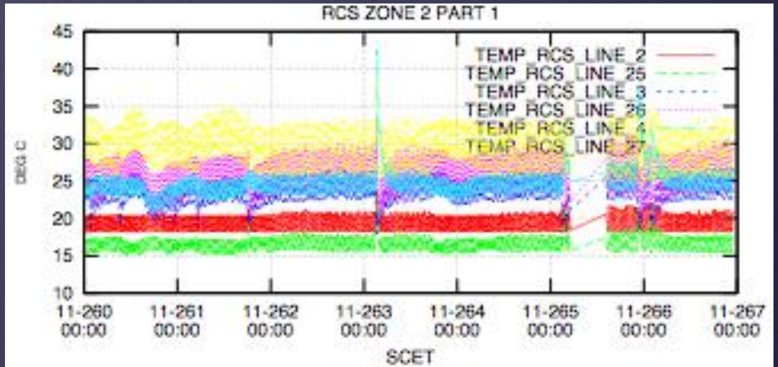


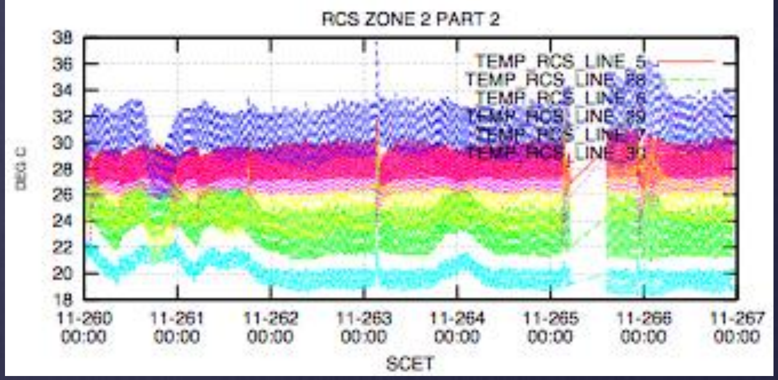
Dawn Thermal Lessons Learned

1.) Some thermal zone covers too broad of an area.

Case: RCS Zone 2

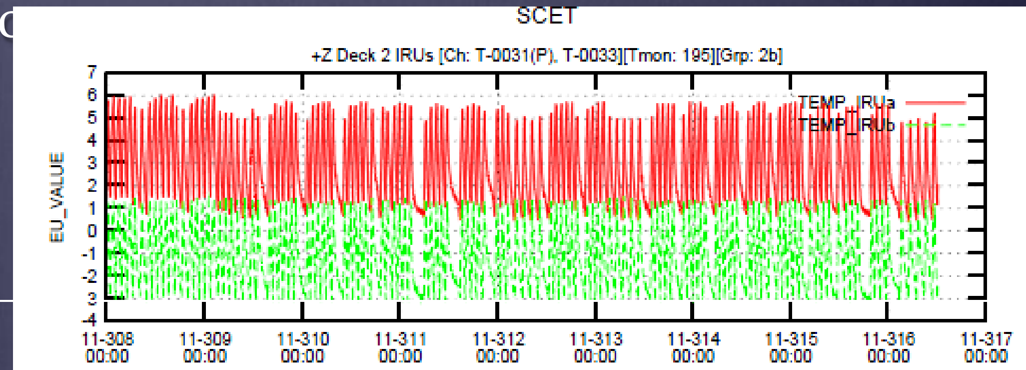


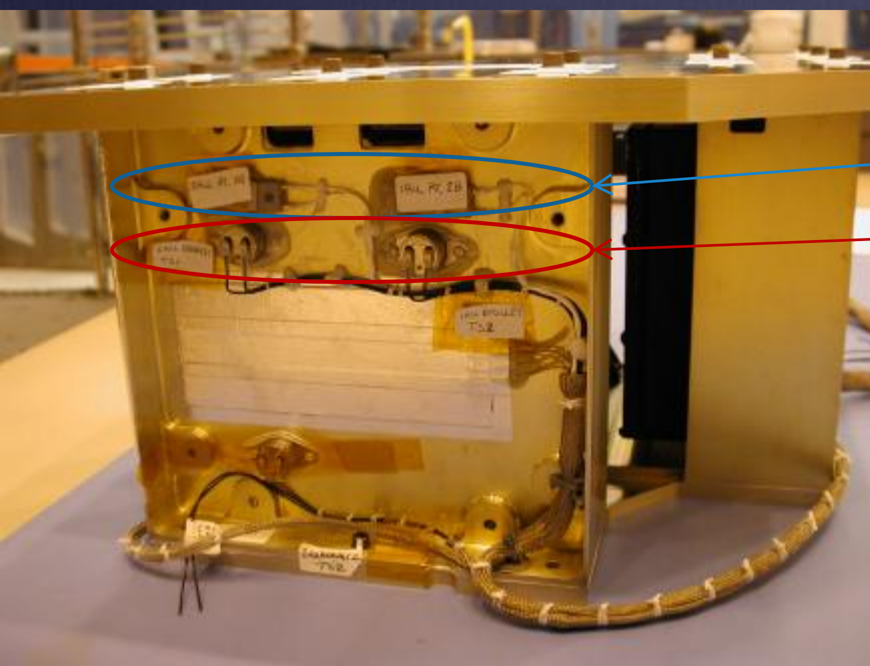




Continued (Zones Too Broad) IRU Brackets

- Flat ‘off’ temperature due to IRUBracket
  - TS1 & TS2





IRUb temp sensors

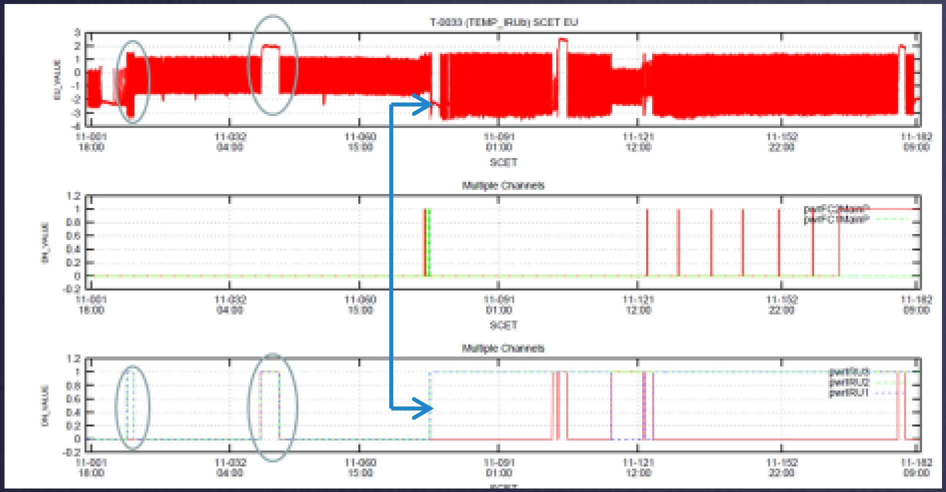
IRUBracket TS1 & TS2

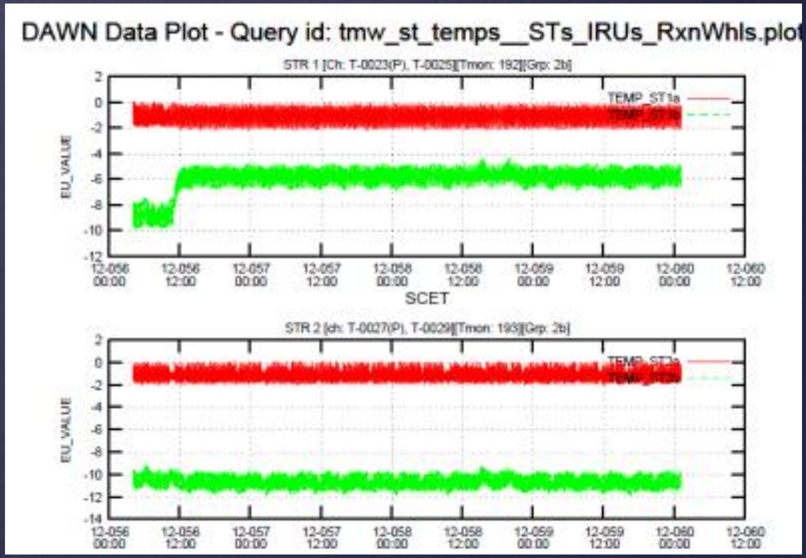
- The ‘red’ IRU controls the circuit causing ‘green’ IRU to run too cold (protected by thermostats).

Dawn Thermal Lessons Learned

2.)Heaters overcompensating, i.e. powering on an instrument or device makes it “colder”

Case: IRUs, Star Trackers





Dawn Thermal Lessons Learned

- 3.) No clear documentation of where all the PRTs are located.

Case: Solar Panels, IPS system.

- 4.) Lack of clear thermal system controls and spacecraft thermal software

"Would be nice to see have a single knob in the software to turn up the PWM heaters:

- 5.) Thermal Model too complicated; each case takes one whole day to run.

Acknowledgments

JPL/Dawn Thermal Engineers: Howard Tseng, Patrick Wu, Shonte Tucker, Dave Wasson (Orbital), and Dawn Flight Team.